DP-MS-85-162

MOBILE MEASUREMENT OF AN ATMOSPHERIC TRACER

by

R. C. Milham, A. H. Weber, and R. A. Sigg

E. I. du Pont de Nemours and Company
Savannah River Laboratory
Aiken, South Carolina 29808

A paper accepted for presentation at the
5th Joint Conference on Applications
of Air Pollution Meteorology with APCA
and for publication in the Proceedings
Chapel Hill, NC
November 18-21, 1986

This paper was prepared in connection with work done under Contract No. DE-AC09-76SR00001 with the U.S. Department of Energy.

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DISCLAIMER

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1. SUMMARY

Atmospheric tracers have been used for several years to test the predictions of atmospheric dispersion codes used for emergency response operations at the Savannah River Plant (SRP). A new mobile analyzer has been tested that allows the continuous measurement of the tracer gas, sulfur hexafluoride (SF_6). Concentrations of the atmospheric tracer can be measured in realtime in the parts per trillion (ppt) range with the mobile analyzer. These measurements quickly indicate the precise location of a tracer plume intentionally released from a stack at SRP. A display of the concentrations of the tracer as the mobile analyzer transects the plume shows the distribution of the tracer.

The commercially available mobile analyzer is a continuous gas chromatograph, which eliminates the expense of placing and collecting stationary samplers in the field, and eliminates the delay of subsequent analysis in the laboratory. It also provides flexibility in data collection if wind speed or direction change during data collection.

2. INTRODUCTION

Atmospheric transport is a primary mechanism by which radionuclides can be brought into contact with people. The Savannah River Laboratory (SRL) has several research programs to improve knowledge of atmospheric transport and dispersion at distances of 10-100 km downwind from the point of release. One of these programs is Mesoscale Atmospheric Transport Studies (MATS). This program was undertaken to provide data for determining the accuracy of mesoscale atmospheric dispersion model predictions for short-term releases (15 minutes).

The MATS experiments provide information on crosswind and downwind spread of material. The horizontal spread in earlier work was obtained with a crosswind series of automatic, stationary samplers, while downwind spread was measured by collecting a sequence of continuous, relatively short-time samples as the plume moved downwind. It was assumed that the structure of the plume changed slowly as it moved across the sample arc.

The tracer gas SF_6 is used for dispersion experiments in these programs. This paper describes a mobile analyzer used to measure SF_6 concentrations in the atmosphere in the ppt range.

A mobile analyzer has significant advantages over stationary samplers. It provides immediate survey measurements in the field with good accuracy so that a plume of SF_6 intentionally released from SRP can be located quickly. It avoids the costly technique of placing and collecting several dozen automatic, sequential air samplers in the field, followed by individual sample analysis in the laboratory. Another important advantage of this technique is that last minute shifts in wind direction or velocity can be accommodated easily. In addition, the same plume can be measured at several distances from the source as the plume moves downwind. The analyzer can be operated day or night to obtain data under a wide variety of meteorological conditions.

3. METHOD AND PROCEDURE

3.1 Release of Tracer

In each test about 100 kg of SF_6 are released at a constant rate over a 15-minute period from a 60-m stack to form a plume. The vertical exhaust velocity at the top of the 3.3-m-dia stack is 6.7 m/s. The effluent is atmospheric air used in the ventilation of a nearby building, and its temperature upon release is reasonably close to ambient temperature (except in the colder months). Since there are no significant structures (greater than 0.4 stack height) within 10 stack heights horizontally of the release point, no building wake effects exist.

3.2 Instrumentation

Mobile measurements are made continuously with a special gas chromatograph made by AeroVironment, Inc., Monrovia, CA. This instrument is mounted in a mobile laboratory vehicle that contains radiometric instruments for emergency response. The instrument operates on 110 VAC and requires hydrogen and high purity nitrogen. The instrument response is displayed on a strip chart recorder.

3.3 Operation

Outside air is continuously pumped through the instrument by a self-contained diaphragm pump. Oxygen in air interferes with the SF_6 analysis and must be removed. Oxygen is eliminated by adding an excess of hydrogen to the sample air and passing the mixture over a catalyst to form water. The water is removed by a semipermeable membrane with dry nitrogen.

The oxygen-free sample is passed through an electron-capture detector with dry nitrogen carrier. This detector responds to the enormous affinity of SF_6 for electrons. The response is amplified and displayed on a strip chart recorder. The response also is stored in a computer together with the time and location provided by a LORAN navigation system. These data are processed later.

3.4 Procedure

The display of the strip chart recorder is used primarily to determine immediately the location of the plume. Within seconds after entering the plume, an increase in the response of the recorder is observed. Qualitative information about the shape of the plume is obtained by observing the whole trace. Once the plume is crossed, the vehicle is turned around and another transect is made. As many as 16 transects of a single plume have been obtained in night tests under stable meteorological conditions.

During each transect separate outside air samples are collected with 60-mL-volume plastic syringes with hypodermic needles. Each collected sample is sealed in the syringe by inserting the hypodermic needle tip into an ordinary septum. These samples are identified by the collection time and returned to the laboratory for analysis with a Perkin-Elmer Sigma 300 gas chromatograph.

3.5 Calibration

All calibration measurements are made with standard SF_6 air mixtures in the 30-to 10,000-ppt range, prepared by Scott Marrin, Inc., Riverside, CA. Special 20-L Tedlar bags are filled at atmospheric pressure to calibrate the mobile analyzer. The Perkin-Elmer gas chromatographs are calibrated by flushing 10 mL of standard SF_6 gas through a 2-mL coil of tubing and analyzing the 2-mL volume.

4. RESULTS

A typical strip chart recording of a transect 40 km downwind of the release point is shown in Figure 1. The precision is ±20 ppt in the 0-to 1,000-ppt range. These results correspond to those obtained with automatic samplers and syringe samples.

5. CONCLUSIONS

This paper describes a mobile analyzer for sulfur hexafluoride (SF_6), an atmospheric tracer. A commercial instrument is used on-board a moving vehicle to measure tracer concentrations in the parts per trillion (ppt) range. This instrument provides rapid, in-the-field data at minimum cost.

6. ACKNOWLEDGMENT

The information contained in this paper was developed during the course of work under Contract No. DE-AC-09-76SR00001 with the U.S. Department of Energy.

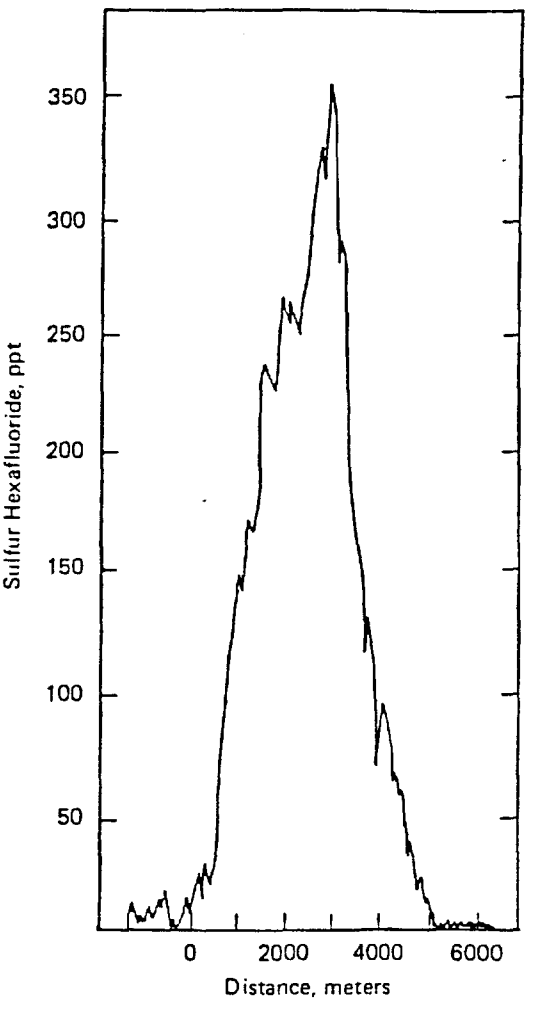

Fig. 1. Typical SF_6 Peak Measured with the Mobile Chromatograph.

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